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VOL. XXIV NO. 1

MICRO-STRUCTURE AND PROBABLE ORIGIN OF FLINT-LIKE SLATE NEAR CHAPEL HILL, NORTH CAROLINA

H. N. EATON

Two miles south of Chapel Hill, North Carolina, along the bed of a small stream known as Morgan's Creek occur extensive exposures of a series of rocks whose general strike is east and west. From Purefoy's Mill on the Pittsboro road eastward along the stream bed to a point three miles distant on the Mason farm, these rocks are of the same general character, and consist of a series of conglomerates, sandstones, and flint-like slates lying in places upon felsite, and dipping southward 50 to 70 degrees. Sills of fine grained acid and basic igneous rocks are frequently found intercalated in this series, and all the rocks are cut by a set of basic dikes. The flint-like slates alone form the basis for the present paper.

This series of rocks has often been included in a great formation of slates and schists of debatable age, extending from Virginia

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(Add to table of contents.)

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southwesterly across central North Carolina into South Carolina, and known as the Carolina Slate Belt. Ebenezer Emmons[1] placed all these rocks in his Taconic system, and W. C. Kerr[2] considered that they belonged to the Huronian. Without considering the vexed question of age, we turn to the views expressed by former writers as to the origin of the flint-like, slaty members of the series.

As early as 1822 the existence of novaculite in Orange County, North Carolina, was noted by Denison Olmstead[3]. In 1828 the same writer[4] again mentioned the novaculite of the slate formation, and stated that the most valuable bed was found at McCauley's quarry, seven miles west of Chapel Hill. The rock here is olive green in color, has a horny look, and is transparent on thin edges.

Emmons[5] described this rock under the head of quartzite as follows: "Color, bluish black passing into purple, grayish, white and green of several shades, and sometimes banded; texture, fine when compared with the finest sandstones; translucent on edges; fracture, flat-conchoidal and frequently brittle, or it may be tough in the mass, but small pieces easily chip off with a light blow. It passes on the one hand into a fine grit, and on the other, into the compact slate and a condition like flint. When struck with the hammer, it is sonorous like cast iron. It is rarely if ever a simple substance like limpid quartz as it usually weathers and loses thereby its homogeneity; besides it is often porphyritic or porphyrized, and frequently the fresh fracture is dotted with small limpid crystals of quartz, which crystalized out from the mass when it was in a semi-fluid state."

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[1] Geological Report of the Midland Counties of North Carolina, New York, 1856, pp. 38-73.

[2] Report of the Geological Survey of North Carolina, vol. I Raleigh, 1875, pp. 131-139.

[3] American Journal of Science, Series 1, vol. 5, 1822, p. 262.

[4] American Journal of Science, Series 1, vol. 14, 1828, p. 238.

[5] Ibid. pp. 69-70.

Albert Williams, Jr,[1] writing in 1888, stated that novaculite was quarried on an extensive scale a few miles west of Chapel Hill.

In his monograph on the Arkansas novaculite, published in 1892, L. S. Griswold[2] cites the above references to Olmstead and Albert Williams, Jr. This writer, in the course of a description of that type of novaculite known as the "Arkansas Stone", says, "The only other stone in this country which resembles the Arkansas Stone and is worked, is that of North Carolina, but the greasy talcose appearance of the latter suggests that its internal structure differs from that of the true novaculite."

H. B. C. Nitze[3], in 1896, describing the rocks of the Carolina Slate Belt, writes thus under the heading, "Quartz Rocks—The Volcanic Series":

"The crypto- crystalline varieties of quartz (flint, chert, hornstone, agatized, chalcedonic) are of especial interest, and warrant a careful consideration. It is again deplored in this connection that the present report did not allow the time for a microscopic study of the thin sections. Such cherty, flint-like masses have been described from the Sam Christian, Moratock, Silver Valley and Hoover Hill mines. It is at present the opinion that these rocks belong to the class of ancient (pre-Cambrian) acid volcanics, and in many respects analogous to, and probably contemporaneous with, similar rocks of South Mountain in Maryland and Pennsylvania, whose discovery was first announced by the late Dr. Geo. H. Williams[4]. Miss Florence Bascom[5] has described the origin, devitrification and structure of the acid types of these rocks. Dr. Williams[6] has outlined the general distribution of the ancient vol-

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1 Mineral Resources of the United States, Calendar year 1887, Washington, 1888, p. 772.

2 Annual Report of the Geological Survey of Arkansas for 1890, vol. 3, 1892, Whetstones and the Novaculites of Arkansas, pp. 21 and 22.

3 North Carolina Geological Survey, Bull., No. 3, Gold Deposits of North Carolina, by H. B. C. Nitze and G. B. Hanna, 1896, pp. 37-38.

4 The Volcanic Rocks of the South Mts. in Pa. and Md., Am. Jour. Sci., vol. 44, Dec., 1892, pp. 482-496. Scientific American, Jan. 14, 1893.

5 Journal of Geology, vol. I, 1893, pp. 813-832.

6 Ibid. vol. 2, 1894, pp. 1-31.

canic rocks along the eastern border of North America. These rocks are analogous to the hälleflintas and eurites of Southern Sweden, described as volcanic rocks by Nordenskjöld. They would also correspond to Hunt's pre-Cambrian petro-silex rocks, called by him the Arvonian, being below his Huronian.

"The hornstones have every appearance of being acid feldspar-quartz rocks, and will probably be found, on further study, to belong to the class of apo-rhyolites, a term introduced by Miss Bascom to denote a devitrified rhyolite. Emmons[1] describes the type very well under the head of quartzite. They resemble perfectly crypto-crystalline quartz, and on weathering present an earthy, yellowish surface. The color of the fresh rock is drab, bluish to almost black; translucent on edges; fracture flat conchoidal; sometimes banded, showing flow structure, etc." On pages 41 and 42 of the same report the following is quoted from Dr. Williams'[2] article: "'In a drive from Sanford to Chapel Hill an abundance of the most typical ancient lavas, mostly of the acid type, was encountered'" - - - - "'Another locality in the volcanic belt was visited on Morgan's run, about 2 miles south of Chapel Hill. Here are to be seen admirable exposures of volcanic flow and breccias with finer tuff deposits, which have been extensively sheared into slates by dynamic agency.'" The above is repeated verbatim by the same author[3] the same year (1896) in an article entitled, "Some Late Views of the So-called Taconic and Huronian Rocks in Central North Carolina."

The tenor of those parts of Nitze's paper just quoted referring to the origin of the fine grained quartz rocks, seems to be that these rocks are closely connected with the ancient surface lava flows which are so common throughout the region. He states that none of them were examined miscroscopically, but suggests that the hornstones will probably be found to be apo-rhyolites. The references to the work of Dr. Williams and Dr. Bascom on the structure and devitrification of ancient acid lavas show that Nitze

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1 Geological Report, Midland Counties of N. C., New York, 1856, p. 51.
2 Journal of Geology, vol. 2, 1894, pp. 1-31.
3 This journal, vol. 13, Part Second, July- Dec., 1896, pp. 53-72.

considered the formation of the hornstones and flinty slates as due to a change in the latter rocks. The existence of tuff deposits along this part of Morgan's Creek mentioned by Williams and quoted by Nitze is strongly discredited by Professor Collier Cobb, who has had occasion to learn thoroughly the structure of the region in question during the course of his work at Chapel Hill. Professor Cobb, however, takes his classes to such tuff deposits southwest of the village, and it is these that Williams and Nitze have evidently confused with the slates of Morgan's Creek two miles south of Chapel Hill.

As Professor Cobb has pointed out to the writer, these slates are bedded alternately with sandstones and conglomerates. The conglomerates are composed of well-rounded pebbles of several kinds of volcanic rocks, but are by no means volcanic agglomerates. The slates are coincident in dip with the sandstones and conglomerates with which they are associated, and, from all field evidence obtainable, seem to have been deposited as regular members of the sedimentary series.

Specimens of the rock for investigation were obtained near the dam at Purefoy's Mill. The general macroscopic description given by Nitze applies very well to the rock from this locality. In handspecimen, the rock is olive green in color, weathering to brownish clay; banding faint, becoming more apparent on a weathered surface; appearance waxy; structure dense and compact, with occasional minute reflecting crystal surfaces; translucent on edges; fracture conchoidal; very brittle; hardness 6.5. Its resistance to abrasion is evidenced by the fact that all of the arrow heads and spear heads of primitive man found in the vicinity of Chapel Hill are made of this material.

Microscopically, this slate is seen to be a true crypto-crystalline rock, containing the minerals feldspar, quartz, kaolin, and epidote. The groundmass is composed of very fine quartz crystals and minute feldspar fragments through which kaolin scales are plentifully scattered. Larger crystals of feldspar form a prominent feature, and occur individually or in groups throughout the groundmass. Sections cut at right angles to the lamination show that the kaolin scales occur in distinct bands varying in width

from .25 to 1.1 mm. To the existence of these bands is due the laminated appearance of the rock in hand specimen. In some cases, also, there seems to have been a rough assortment of the larger feldspars in bands, although this occurrence was not observed to be universal.

The feldspar is plagioclase, and occurs in crystals varying in size from the very minute particles of the groundmass up to .286 mm. in diameter. The average diameter of the larger crystals is from .065 to .1 mm. The form is usually sub-angular, although rounded crystals are seen, suggestive of a clastic derivation. All the crystals polarize separately. Some crystals are intimately interlocked. Others have deep re-entrants into which the silica of the groundmass protrudes, suggesting a partial resorbtion of the feldspar by the groundmass? Albite twinning is universal, the maximum angle of the striations in the zone perpendicular to M lying between 10 and 16 degrees. Hence the plagioclase mixtures lie between basic oligoclase and andesine. The crystals show little if any decomposition. The largest feldspar noted, .286 mm. in diameter, is nearly round, is completely eneased in a thin rim of greenish glass, and lies in a rubble of small angular feldspar fragments.

The crystals of the groundmass all polarize separately and exhibit low interference colors. The grains are extremely irregular in outline, and are closely intelocked. The average diameter is .015 mm. Many of these grains are seen to be plagioclase from the albite striations. Many are quartz, but owing to the difficulty of distinguishing between quartz and feldspar in very small angular fragments, it is not possible to state definitely the percentage of each mineral. That much free silica is probably present, however, is indicated by the high total percentage of silica in the rock.

Kaolin occurs in minute scales. In the narrow bands above noted, kaolin is by far the most abundant mineral, and the scales lie very close together. It is likewise found in less abundance in every part of the rock. The diameter of the scales varies from .0026 to .0052 mm.

Epidote occurs rarely in minute grains in small clusters. The interference colors are of a low order.

A partial analysis of the rock by Dr. A. S. Wheeler, associate professor of Chemistry in the University of North Carolina, gives the following results:

Silica	77.54 per cent.
Alumina	13.51 per cent.
Iron oxide	1.17 per cent.
Lime	1.10 per cent.
Magnesia	0.23 per cent.

This analysis confirms the microscopic determination.

Hand specimens and thin sections of a somewhat similar fine grained siliceous rock from Gold Hill, N. C., collected last summer by Mr. F. B. Laney of the North Carolina Geological Survey, were lent the writer by the State Geologist, Dr. Joseph Hyde Pratt. A hasty examination of thin sections of the latter rock reveals its close resemblance to the Purefoy's Mill material, the main difference between the two being that the feldspars in the Gold Hill rock are uniformly larger.

Griswold[1] defines novaculite as "a fine-grained, gritty, homogeneous, and highly siliceous rock, translucent on thin edges, and having a conchoidal or sub-conchoidal fracture." The Purefoy's Mill rock differs from the Arkansas novaculites in its lower silica content, and in containing kaolin and feldspar in abundance. It resembles the true novaculites in its general physical character.

SUMMARY AND CONCLUSIONS AS TO ORIGIN.

Field evidence shows that the flint-like slate found at Purefoy's Mill is a member of an undoubted sedimentary series, with distinct lamination or stratification coinciding in dip with the other members of the series. Microscopic study reveals the fact that a mechanical sorting and arrangement of the kaolin particles in layers took place prior to consolidation.

Professor Cobb is of the opinion that the rock owes its origin to the consolidation of fine volcanic sand sorted by and deposited in deep water, or that the sediment may have been derived from the

(1) Annual Report of the Geological Survey of Arkansas for 1890, vol. 3, p. 18.

felsites and rhyolites on which it rests, its crystalline structure being due to subsequent metamorphism.

The writer, rather, believes that the rock has remained essentially unchanged since its consolidation, and that its formation was similar to that of arkose, viz: that its component minerals are the detrital fragments of a rock or rocks rich in quartz and feldspar. Many of the feldspars are rounded, suggesting a clastic origin, and are roughly arranged in layers parallel with the kaolin bands. The chemical analysis, as far as it was carried out, is very much like the analysis of the average rhyolite, and it is highly probable that the materials of which the rock is composed were derived from such acid volcanic rocks as occur in great abundance in the vicinity.

The writer wishes to express his indebtedness to Professor Cobb for suggestions in preparing this paper, and also to Dr. Pratt and Mr. Laney for kindly loaning him material for comparison.

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University of North Carolina,
Chapel Hill, N. C.

FIELD FOR ECONOMIC PLANT BREEDING IN THE COTTON BELT*

DAVID R. COKER

In considering any subject related to the present condition of Southern Agriculture, it is well to remember that our section has not completely recovered from the effect of the civil war and the ensuing period of negro rule. This cannot be but plain to the student of Southern Agricultural conditions and is largely caused by the almost complete paralysis of our educational system during and for some years after the war.

A large percentage of our farmers, not having had the opportunity to obtain an education, have been unable to keep full pace with the advance of their profession. The influence of our Agricultural Colleges and the missionary work of such men as Dr. J. M. McBryde, Col. J. S. Newman, Prof. W. F. Massey, Mr. E. McIver Williamson and Editors Jackson and Hunnicutt are, however, plainly evident in the general and rapid improvement of conditions.

Though great advances along many lines have been made, the subject of plant breeding and its vital relation to agriculture has hardly begun to attract attention in our section. Scarcely any of our farmers have the slightest conception of what plant breeding means, and there is now almost no supply of pedigreed seed of any of our staple crops. Our farmers, however, can be counted on to buy scientifically bred seed and devote some attention to seed selection, as soon as the great value of pure breeding is impressed upon them. Our Agricultural Colleges and farm journals have a gread field for missionary work on this subject, which, as yet, they have scarcely touched.

*Read before the American Breeders Association, Washington, D. C., January 30th, 1908.

There are for sale in the South numerous so called varieties of seed which are advertised under high sounding names and with most extravagant claims of productive capacity. Many of these, however, prove to be mixtures of types and are frequently found to be worse than valueless. Plant breeders, as well as farmers, would welcome an effort by the National and State Governments to stop this pestiferous class of swindling, and I hope the Association will take some steps to this end for the general good and protection of its members.

The importance of plant breeding to the south cannot better be shown than by calling attention to the value of some of the work that has already been done.

The earliest work of this kind that is known of by the writer was undertaken before the war by Hon. John Townsend of Edisto Island, who succeeded in improving a strain of Sea Island cotton until its length was about two inches. I am informed that he invariably got $1.00 or more per pound for this cotton as long as he lived. Other Sea Island planters have kept up a more or less perfect system of breeding to the present day, and to this, in part at least, is undoubtedly due to the admitted pre-eminence of South Carolina Sea Islands.

Valuable varieties of upland long staples have been originated by Mr. Allen and Mr. Griffln of Mississippi and Mr. Stoney and Prof. C. L. Newman of South Carolina. Prof. Newman has also done some remarkable work on field peas.

The experiment Stations of all the cotton states are, I believe, now doing more or less plant breeding, but most of their work has not advanced far enough to have general effect on agricultural conditions.

The work of the National Plant Breeding Department, under the direction of Dr. H. J. Webber, stands preeminent in the breeding of those of our economic plants to which attention has been given.

The success of this department with pineapples, citrus fruits, cotton and tobacco are no doubt more or less familiar to all of this audience.

The Columbia, bred by Dr. Webber personally, is the first of his cottons to be distributed by the Department of Agriculture.

It has yielded with the best of the varieties tested at our State Experiment station, and its money out-turn was the greatest of any, on account of the premium which its long staple commands.

My own experiments with this cotton seem to coincide with those obtained at Clemson the last season. I tested it with nine other varieties and, though the general results were not conclusive, owing to irregularity of stand, Columbia undoubtedly stood first in money value.

Dr. Webber's Citranges are also an important addition to our economic plants, as they provide an entirely new class of fruits for the cotton belt.

A plant of Rusk Citrange which fruited in my garden last season has thus far proved entirely hardy. The delicious ade made from this fruit may soon be expected to alleviate the situation in the broad area of southern prohibition territory.

I would like to mention the work of a number of the men in the Bureau of Plant Breeding, but refrain from lack of space. I *must* say, however, that Mr. A. D. Shamel has obtained results with shade grown tobacco that deserve the widest notice and commendation. He has, in fact, revolutionized that industry. Mr. Orton also, in saving the cotton plant from extinction over considerable areas, has earned the gratitude of the cotton states.

The production of varieties of cotton similar to Columbia, suited to each section of the south, is one of the most promising opportunities now in view for southern plant breeders. This work is especially important to the eastern part of the belt where upland cottons average less than one inch in length of staple and sell in the markets of the world at a lower price than any except East Indians.

It should be noted that most of Dr. Webber's promising new cottons, including Columbia, originated with selections from existing varieties and not from hybrids.

My method of cotton breeding is similar to that originated by Dr. Webber, but differs in a few details. I started with a determination to breed, if possible, an up-land cotton of maximum production that would command a staple premium. All extra staple varieties then known to me were much lower in yield than

the best short staple sorts. I have, therefore, from the first examined only the most productive plants, and of these only the ones which show an increase in length of lint are selected for breeding. I give the plants a distance of 4 by 4 or 5 by 5 feet and have incidentally made the interesting discovery that on good soils these distances produce more cotton than the usual farm method of crowding in the drill. I find it a good plan to have two breeding plats, one on heavy and one on light soil, putting part of the seed of each mother plant on each plat under the same breeding number. Before selection is begun I take one seed with lint attached from each of a dozen plants on each breeding row and mount them. By a comparison of these a quick approximation can be made of the average performance of each breeding number in length and percentage of lint. Selections are then made from every number not palpably deficient in some cardinal point, for I find it impossible to judge with the eye the relative yield of different rows of cotton. A record of the exact yield of each row on both plats is, therefore, kept and if the same number shows maximum yields as well as other desirable qualities on both the light and heavy soil rows, there can be little question of the inherent quality of the selections made from it. Selections from rows of poor yield are, of course, discarded unless very exceptional.

My best number last season showed a production about 10 per cent greater in both plats than any other row. It was also quite satisfactory in length and percentage of lint, largeness of boll and other desirable characteristics, and I hope to make from it a variety as good as, or better than Columbia.

The low yield of corn throughout the cotton belt is presumptive evidence of both poor seed and inferior cultural methods.

The latter is being rapidly remedied, largely through the agitation begun by Mr. E. McIver Williamson of my own County, (Darlington County, S. C.) who has perfected a method of culture that not only produces large crops, but rapidly improves the soil.

Such corn breeding work as is now being carried on so generally and successfully in the middle states is almost unknown to the South. Here and there, intelligent farmers have improved

their own seed by selection in the field. None of them, however, that I know of has resorted to pedigreed breeding, and if any acclimated corn of pure pedigree is being offered to the farmers of the cotton belt, I do not know of it.

My own work, begun only a year ago, indicates as great variability in the yielding power of individual ears as has been noted by Mr. J. Dwight Funk and Prof. C. G. Hopkins of Illinois. A most notable result in my experiments was the absolute failure of the seed ear which in all visible points was best.

The limits of this paper do not allow mention of the breeding requirements of each of the many southern economic plants. Suffice it to say that nearly all of them (and their number is legion) can be greatly improved in quality and productive capacity by systematic breeding.

The record of southern plant breeding is, as yet, very short. Here and there, work has begun and quick and valuable results have invariably followed; but compared with what yet remains to be done, that already accomplished is indeed small.

No fairer or broader field exists in American Agriculture today than the field for economic plant breeding in the Cotton Belt.

HARTSVILLE, S. C.

NOTES ON THE LIFE-ZONES IN NORTH CAROLINA

C. S. BRIMLEY AND FRANKLIN SHERMAN, JR.

The old-established popular division of North Carolina into eastern, middle, and western sections, is familiar to us all. It is an interesting fact that a study of the available zoological records gives a somewhat similar division of the state into life-zones or areas.

This detailed study of the animal life of the state shows that, while a small number of species are widely distributed throughout all sections of the state, yet the majority show in some degree, a more or less restricted range within our borders, — and it is upon a study of all available records of these restricted forms, that our provisional map of the life-zones of the state is based. In these studies we have depended mainly on mammals, reptiles and batrachians. Fishes have been practically omitted, and birds and insects owing to their powers of flight and tendency to wander, have been used chiefly for confirmation, and even then we have relied principally on records of breeding birds, which would be more likely to be within their proper range.

It has been known that four of the recognized life-zones of North America are represented in our state. These are: — 1st, the Canadian, — 2nd, the Alleghanian (or Transition), — 3rd, the Upper Austral (or Carolinian), — 4th, the Lower Austral (or Austro-riparian.)

1. *The Canadian Zone* in this state includes only the tops of the higher mountains. Aside from a few scattered records the places from which we have sufficient data to positively mark as belonging to this zone are, the higher altitudes in the Black Mountains, Roan Mountain, Grandfather Mountain (including

Blowing Rock), Bald Mountain in Yancey County, and the higher mountains in the vicinity of Highlands in Macon County,—although it is practically certain that more extended collecting and observation will show that this same zone includes also the tops of some other mountains, especially the Balsams, Mount Toxaway, and Pisgah Ridge. This zone does not extend below an elevation of 4,500 feet. The animals known to occur in this zone in this state and which do not normally extend into the zones of lower elevation, are named below. We include those species of birds whose nesting habitat is in this zone, though the same birds may of course be found in other zones when not nesting.

Mammals:

Carolina Red-backed Mouse (Evotomys Carolinensis).
Canadian Deer-mouse (Peromyscus canadensis).
Woodland Jumping-Mouse (Napaeozapus insignis).

Birds (breeding):

Golden-crowned Kinglet (Regulus satrapa).
Red-breasted Nut-hatch (Sitta canadensis).
Brown Creeper (Certhia familiaris).
Winter Wren (Olbiorchilus hyemalis).
American Cross-bill (Loxian minor).
Pine Siskin (Spinus tristis).
Carolina Junco (Junco hyemalis carolinensis).

Batrachians:

Black Salamander (Desmognathus nigra).
Purple Salamander (Spelerpes porphyriticus).
Yellow Salamander (Desmognathus ochrophea).

2. *The Alleghanian Zone* embraces a large part of our mountain region, including practically all between the elevations of 2,500, and 4,500 feet. In our map we have conservatively restricted this zone to the higher known ranges. We have record of the following species which are characteristic of this zone as contrasted with the more highly-elevated Canadian zone:

Mammals:

Common Flying-squirrel (Seiuropterus volans).

Deer-mouse (Peromyscus leucopus).
Pine-mouse (Microtus pinetorum).
Cotton-tail Rabbit (Lepus floridanus mallurus).
Dusky Bat (Vespertilio fuscus).
Common Mole (Scalops aquaticus).

Reptiles and Batrachians:

Viscid Salamander (Plethodon glutinosus).
Red Triton (Spelerpes ruber).
Hellbender (Cryptobranchus alleghaniensis).
Ground Snake (Carphophiops amoenus).
Chicken Snake (Coluber obsoletus).
Banded Rattlesnake (Crotalis horridus).

As the above-named species distinguish this zone from the Canadian, just so the following species distinguish it from he lower and warmer Upper Austral zone.

Mammals:

Star-nosed Mole (Condylura cristata).
Brewer's Mole (Scapanus breweri).
Smoky Shrew (Sorex fumeus).
Red Squirrel (Sciurus hudsonius).
Wood-chuck (Artomys monax).

Batrachians:

Daniel's Salamander (Spelerpes danielsi).
Mountain Salamander (Desmognathus quadrimaculatus).

3. *The Upper Austral Zone* seems to include (roughly speaking) all of our territory north and west of a line drawn from Suffolk, Va. to Raleigh, thence to Charlotte, and thence a little south of west to the South Carolina line at or near Tryon in Polk County, —except that part of the mountain region occupied by the Alleghanian and Canadian zones. The animals which occur in this zone in this state and which are generally considered to distinguish it from the higher and colder Alleghanian zone are:

Mammals:

Opossum (Didelphis virginianus).

Gray Fox (Urocyon cinereo argenteus).
Golden Mouse (Peromyscus nuttalli).
Little Mole Shrew (Blarina parva).
Twilight Bat (Nycticeius humeralis).
Georgia Bat (Pipistrellus subflarus).

Reptiles and Batrachians:

Marbled Salamander (Amblystoma punctatum).
Holbrook's Triton (Spelerpes guttolineatus).
Ground Lizard (Liolepisma laterale).
Brown King-snake (Ophibolus rhombomaculatus).
Muhlenberg's Terrapin (Chelopus muhlenbergi).

And this same zone is distinguished on the south and west by having the following animals whose range does not normally extend into the Lower Austral zone.

Mammals:

Chipmunk (Tamias striatus).
Deer-mouse (Peromyscus leucopus).
Cooper's Lemming (Simaptomys cooperi).
Meadow Mouse (Microtus pennsylvanicus).
Jumping Mouse (Zapus hudsonius).
Weasel (Putorius novaboracensis).
Mole Shaew (Blarina brevicauda).
Red Fox (Vulpes fulvus).

Reptiles and Batrachians:

Common Water-snake (Natrix fasciatus sipedon).
Wood Frog (Rana sylvatica).
Pickerel Frog (Rana palustris).
Red-backed Salamander (Plethodon erythronotus).

4. *The Lower Austral Zone* includes all of our territory south and east of the line already described for the eastern and southern boundary of the preceding (upper austral) zone. The number of animals occurring in this state in this zone but not ordinarily extending into the Upper Austral Zone is quite large, and includes the following:

Mammals:

Southern Fox Squirrel (Sciurus niger).
Cotton Mouse (Peromyscus gossypinus).
Cotton Rat (Sigmodon hispidus).
Rice-field Rat (Oryzomys palustris).
Roof-rat (introduced) (Mus alexandrinus).
Marsh Rabbit (Lepus palustris).
Southern Shrew (Sorex longirostris).
Carolina Mole Shrew (Blarina carolinensis).
Big-eared Bat (Plecotus mocrotis).

Birds:

A considerable number might be mentioned but are not needed to confirm the zone.

Reptiles:

Alligator (Alligator mississipiensis).
Joint Snake (Ophysauris ventralis).
Green Lizard (Anolis principalis).
Southern Water-snake (Natrix fasciata).
Pied Water-snake (Natrix taxispilota).
Hoop-snake (Abastor erythrogrammus).
Horn-snake (Farancia abacura).
Striped Chicken-snake (Coluber quadrivittatus).
Spotted Racer (Coluber guttatus).
Brown-headed Snake (Rhadinea flavilata).
Red King-snake (Ophibolus coccineus).
Red Snake (Cemophora coccinea).
Hog-nosed Snake (Heterodon simus).
Crowned Tantilla (Tantilla coronata).
Cotton-mouth Moccasin (Akistrodon piscivorus).
Ground Rattle-snake (Sistrurus miliarius).
Diamond Rattle-snake (Crotalus adamanteus).
Smooth Terrapin (Pseudemys concinna).
Florida Terrapin (Pseudemys floridanus).
Rough Terrapin (Pseudemys scripta).

Batrachians:

Carolina Tree-frog (Hyla cinerea).
Squirrel Tree-frog (Hyla squirella).
Pine-woods Tree-frog (Hyla femoralis).
Dwarf Toad (Bufo quercicus).
Narrow-mouth Toad (Engystoma carolinense).
Margined Salamander (Stereochilus marginatus).
Dwarf Salamander (Manculus quadridigitatus).
Mole Salamander (Amblystoma talpoideum).
Ditch Eel (Amphiuma means).
Southern Water-dog (Necturus punctatus).
Mud Eel (Siren lacertina).

In outlining this map the most important step has been to locate the line separating the lower and upper austral zones. In placing this line where we have it, we have been influenced by the following data: The Dismal Swamp region, which lies partly in the northern end of Camden county, is known to have decidedly lower austral affinities, so that our line would seem to start west of this swamp. The only section in the northeast part of the state which has enough records to furnish a reliable guide is the southeastern part of Bertie county, where Sans Souci and Avoca have on record five distinctively lower austral forms, to two upper austral. Meagre data from Jackson (Northampton County) and Tarboro (Edgecombe Co.) indicate a mixed fauna at both places, and therefore we have run the line between them. Raleigh is really the strongest point in locating this line. Abundant data indicates that the fauna of Raleigh and vicinity is thoroughly mixed, with no decided preponderance in either direction,—therefore we have run the line directly through Raleigh. This gives practically a straight line from Raleigh toward Suffolk, Va., until the state line is reached at Chowan River.

West of Raleigh and east of the mountains our data is scant. Cary, with one decidedly upper austral form (Chipmunk) which does not occur at Raleigh, finds a place above the line, while Apex with one lower austral form is below it. It is interesting to note here that the Chipmunk recorded from Cary was taken not more than seven miles from Raleigh but has never been taken actual-

ly at Raleigh, while the Florida Terrapin, (a very decidedly lower austral form) has been taken in north-west Johnston county, but is not known at Raleigh. This gives further warrant for running the dividing line directly through Raleigh.

The line, passing between Cary and Apex, runs straight to Charlotte. Southern Pines, many of whose insects are known, shows strong lower austral affinities, while Stanly and Cabarrus counties each contribute one lower austral record. As Salisbury and Statesville both show records which would tend to exclude them from the lower austral zone, we have run the line straight to Charlotte so as to leave these points in the upper austral, but including parts of both Stanly and Cabarrus counties in the lower austral.

From Charlotte we have run the line slightly south of west, so that it crosses the South Carolina line at or near Tryon in Polk County. This latter locality seems to be (biologically) one of the most remarkable in the state. Its vicinity within a radius of a few miles is so varied in elevation and temperature that we have records of lower austral, upper austral, and Alleghanian forms, and there may be an infusion of strictly Canadian forms on the tops of the higher mountains of that locality. Of the strictly lower austral forms known at Tryon we may mention the Green Lizard, and a species of true Scorpion, the latter having never yet been taken at any other place in the state.

It may be well to mention a few rather exceptional records. Coopers Lemming, — recorded as an inhabitant of sphagnum swamps which are generally considered to present Alleghanian tendencies,—has been taken at Chapanoke in Perquimmans county. The Diamond Rattle-snake, — considered to be a decidedly lower austral form, — has been recorded at Jackson, Northhampton Co. The Red-backed Salamander, — not known at Raleigh and a distinctively upper austral form, — has been taken at Greenville, Pitt Co. At Kinston the Wood-Frog and Pickerel Frog (both considered to be upper austral species) have been taken. The Weasel (upper austral) has been taken at New Bern. The Glass Snake,— a typically lower austral form, — has been taken at Statesville. In Transylvania county there is record of the Mole Salamander, which is a distinctively lower austral form. Insects of normally

lower austral habitat have been taken at Andrews in Cherokee Co. and near Franklin in Macon Co. The Green Lizard (lower austral) is also said to occur along the Little Tennessee River in Graham or Swain Counties, but this record is open to question.

At Weaverville, Buncombe County, the Big-eared Bat (lower austral) has been recorded.

These exceptional records, while in our opinion not sufficiently numerous or consistent to change the course of the faunal lines as shown on the map, serve to emphasize the fact that no faunal lines or zones can be claimed to be absolute. Animals typical of one zone will occasionally wander into a neighboring zone. It is therefore not surprising to find a typically lower austral form as much as twenty to forty miles north or west of the faunal line, or on the other hand to find a distinctively upper austral form a similar distance east or south of this line, — and this overlapping of forms along the edges of the zones occurs with special frequency among those animals which move rapidly from place to place and which may therefore from hunger, fright or other causes become restless and wander out of their normal range. But it would be worthy of note if a *distinctively* upper austral form were found to occur regularly and in any degree of abundance, in the warmer parts of our state which are well within the Lower Austral zone as defined on our map. In this connection we would call attention to the localities of Cape Hatteras, Beaufort, Havelock (Lake Ellis) and Wilmington. From these four localities we get a total of 46 characteristic records, every one of them lower austral. But when we go nearer to the line to the north and west as at Greenville, Tarboro and southeastern Bertie County, we strike scattering upper austral records. The few upper austral records for New Bern and Kinston are of such character as not to materially affect their standing as strictly lower austral localities. The presence of several lower austral records in the southern part of our mountain region is plainly attributable to the proximity of the Gulf coast only a few hundred miles to the south, whence characteristic forms no doubt migrate with more or less frequency up the streams or through the low mountain valleys, — while the high mountain ranges present many Alleghanian and even some Canadian forms. These conditions of life-zones normally opposed to

one another being brought so closely together in the southern part of our mountain section, render it a region of peculiar biological interest.

With regard to this southwestern section of our state, we cannot do better than to quote from an article on "An Ornithological Reconnaissance of Western North Carolina" by Wm. Brewster, published in "The Auk," January, 1886. He says:

> " . . . I have left a valley where Mocking-birds, Bewick's Wrens, and Cardinals were singing in water-oaks, sweet-gums and magnolias (all upper austral birds and plants), climbed a mountain side covered with oaks and hickories inhabited by Wilson's Thrushes, Yellow-throated Vireos and Rose-breasted Gross-beaks (Alleghanian forms), and within an hour or two from the time of starting found myself in a dense spruce forest where Winter Wrens, Golden-crested Kinglets and Red-bellied Nuthatches (Canadian forms) were the most abundant and characteristic birds. Indeed, were it possible in the present state of our knowledge to indicate accurately on the map the relative extent and position of the three faunae (life-zones) by using a different color for each . . . the work when completed would certainly present a strangely patched appearance.
>
> "The boundaries of these divisions are determined chiefly by elevation, the Canadian occupying the tops and upper slopes of the mountains down to about 4,500 ft., the Alleghanian the mountain sides, higher valleys, and plateaus between 4,500 and 2,500 ft., and the Carolinian (upper austral) everything below the altitude last named."

The authors in preparing this map have chosen to be conservative in representing the Alleghanian and Canadian zones, and there is doubtless more territorry actually included in each of these than the map shows. Furthermore, the extreme northwest counties are as yet practically unknown from a zoological standpoint, so that, — while we might assign most of its territory on hypothetical reasoning, we have preferred to leave it unmarked save by an interrogation point.

RALEIGH, N. C.

A BACTERIOLOGIC STUDY OF THE BLANK CARTRIDGE*

DAVID H. DOLLY

It appears from statistics in THE JOURNAL of the American Medical Association, August 29, 1903, that of 392 cases of tetanus incident to accidents on the previous July 4, 363 followed wounds from the blank cartridge and toy pistol. In other words, 92 per cent. of the tetanus cases were apparently attributable to wounds from blank cartridges.

Dr. A. I. Ludlow, assistant resident surgeon at the Lakeside Hospital, succeeded in isolating *B. tetani* from the blank cartridge wounds in one out of five fatal cases of tetanus, but cultivated the *B. aerogenes capsulatus* in four. In none of these cases was there emphysema nor emphysematous gangrene of the wounds, which were routinely treated by free incision and packing with iodoform gauze. In one of these which came to autopsy I failed to isolate *B. tetani* from the wound of the hand, but obtained *B. aerogenes capsulatus* from the local lesion and heart's blood. There was no gaseous emphysema of any organ.

These findings led me to investigate several makes of blank cartridges, and the results of these investigations form the basis of the present paper. The infectious agents concerned in these wounds (apart from the contents of the cartridge), may come from the skin and parts of clothing introduced. These latter sources of infection were not considered.

SOURCE OF MATERIAL

The cartridges used were manufactured by the Peters Cartridge Co., the Winchester Arms Co., and the Union Metallic Cartridge Co., and were bought in the open market at various times and places.

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CULTURAL EXPERIMENTS

(*A*) *Wads.*—In both the cultural and animal experiments the wads were extracted with a sterile instrument, every care being taken to exclude accidental contamination.

The wads were placed in a 1 per cent. glucose bouillon, and incubated under anaërobic conditions (usually in Novy jars) at body temperature, for from 3 to 5 days, when coverslip preparations were studied. Not infrequently slender bacilli with end spores suggestive of *B. tetani* were seen. Nine cultures containing these tetanus-like bacilli were inoculated in fresh hematoma in the thigh of guinea-pigs. All of these animals survived but one, which died at the end of the month without symptoms of tetanus. These tetanus-like bacilli decolorized by Gram and were proved by cultural methods to be identical with a pseudo-tetanus bacillus discovered by Bain in blank cartridges. Many cultures contained a stout bacillus with square ends, apparently encapsulated, and subcultures made on glucose agar showed abundant gas formation. Nine rabbits injected with these gas-forming cultures, and killed ten minutes afterward, showed after from 8 to 20 hours' incubation marked gaseous emphysema, and *B. aerogenes capsulatus* was isolated from them all in pure culture. All efforts to demonstrate the presence of *B. tetani* failed. In a total of 250 wads examined by culture, the *B. aerogenes capsulatus* was demonstrated in sixty-six, or 26.4 per cent., and from sixty-one it was isolated in pure culture. Two of these were worked through all media, but in general the cultural characteristics on glucose agar, milk, and blood serum, together with the morphology, the capsule formation, the positive Gram stain, and the failure to grow aërobically, were deemed sufficient for identification. It is interesting to note that spore formation occurred in old milk and agar cultures, as well as on blood-serum. Some difficulty was experienced in separating *B. aerogenes capsulatus* from the other anaërobic organisms present in wads until Kitasato's method of heating for one hour at 80 degrees C. was adopted. It invariably survived this. That the explosion of cartridges neither kills nor inhibits the growth of *B. aerogenes capsulatus* was demonstrated by shooting the wads into jars containing melted glucose agar, which on incubation gave

abundant growth of this organism in four out of five experiments.

The following table gives the proportinn in which *B. aerogenes capsulatus* was found in wads of the different makes:

	Wads examined	B. A. C.	Per cent.
Peters .32 caliber	54	32	50.9
Peters .22 caliber	50	21	....
U. M. C. .32	49	7	7.0
U. M. C. .22	50	0	....
Winchester .22 caliber	47	6	12.7
	250		

(*B*) *Powder.*—Cultures from the powder of 101 cartridges were usually serile. Neither *B. tetani* nor *B. aerogenes capsulatus* was isolated.

INOCULATION OF ANIMALS

At the suggestion of Prof. William H. Welch, the rat was used as being probably the animal most susceptible to tetanus.

To give *B. tetani*, if present, the most favorable environment possible, use was made of two procedures, the second one of which has not been employed in similar investigations. The first is inoculation of fresh hematoma, which increases greatly the chances of growth of *B. tetani*. As to the second one, Vaillard and Rouget established that "tetanus spores when free from toxin are innocuous when not accompanied by another bacterium, unless protected from phagocytes." Twelve white rats were inoculated under strict asceptic precautions with wads from the Peters Co. 32 caliber cartridges. In addition, a loop of a pure aërobic culture was added, in six an attenuated *Staphylococcus pyogenes aureus* and in the remaining six *B. coli communis*. The skin was then closed by a stitch and covered with celloidin.

Nine of these rats died in convulsions, the tenth quietly, while the other two survived. The incubation period varied from sixty to seventy hours. The character of the convulsions differed from that usually described for animals. The first symptom was a marked spastic condition of the inoculated leg, which was held in extreme flexion, explained by the laceration of the extensor muscles. Gradually this spastic state extended to the whole body, so that the animal would retain its distorted shape in any position. In all, there was emprosthotonos, in two associated with pleurothotonos. The forelegs were held closely against the abdomen and the non-inoculated leg in extension. At short, ir-

regular intervals there were definite convulsions, the most typical of which started with several rapid nods of the head, followed in order by clonic spasms of forelegs and hindlegs, passing in a few seconds into a tonic spasm of the whole body. In several, clonic spasms alone appeared. The convulsions lasted from one and a half to three hours, the animals all dying at the end of a spasm.

At autopsy no lesions of internal organs were found. Smears from the meninges were negative for leucocytes and bacteria. Bearing in mind previous failures to cultivate *B. tetani* from wounds, it was thought wiser to subinoculate from these animals. Accordingly, the wads, with some necrotic tissue, were removed from six of the rats and inoculated into three guinea-pigs and three rabbits. The guinea pigs died during the night, but the rabbits developed tetanus in about thirty hours. The character of the convulsions corresponded to the description in text-books.

In smears from the rats and guinea-pigs, a few spore-bearing bacilli morphologically resembling *B. tetani* appeared. These were somewhat more numerous from the rabbits. From one rat only one such bacillus was seen after an hour's search. In all smears bacilli morphologically identical with *B. aerogenes capsulatus* were recognizable, together with numerous other organisms. Cultures were made from the wounds and wads on glucose bouillon and glucose agar, as well as blood serum. There was marked gas production, but repeated search failed to disclose *B. tetani*. Numerous subcultures, made both with and without Kitasato's method, were likewise negative. *B. aerogenes capsulatus* grew so rapidly and vigorously that it apparently crowded out *B. tetani* Many anaërobic plates were also unsuccessful as regards *B. tetani*. In explanation of these failures, it may be said that the tetanus-like bacilli were extremely scanty, while *B. aerogenes capsulatus* was relatively abundant; and, further, that several other bacilli were present in the Peters wad, which resisted heating as well, one of these forming colonies much resembling those of *B. tetani*.

However, of five rabbits inoculated with five or six loops of the original cultures, three died in convulsions. Smears and cultures from their wounds were also entirely negative for *B. tetani*, though made as soon as symptoms of tetanus appeared.

The experiment was next tried of adding several crystals of urea to the material inoculated for its antichemotactic effect. In this rabbit the exude was poor in leucocytes, and tetanus-like bacilli more numerous than in previous experiments, but *B. aerogenes capsulatus* had increased proportionately and several series of plates were again negative for *B. tetani*.

A second series of inoculations with the Peters wads was next made. Three rats and three guinea-pigs were each inoculated with two wads, together with *Staphylococcus pyogenes mucus*, and several small crystals of urea. One rat and two pigs developed tetanus. As in the previods experiments, tetanus-like bacilli appeared in greater numbers than in the first series, but have not yet been isolated.

Inoculation experiments were also tried with the other brands of cartridges. In the case of the Union Metallic cartridges, the wads from the seven original bouillon cultures which yielded *B. aerogenes capsulatus* were used. One rat died without tetanic symptoms, the others survived. Likewise, thirteen wads of the Winchester cartridges, distributed among three rats and three guiney-pigs, produced no symptoms, and the animals survived the local suppuration produced by the staphylococcus.

Previous work has been done on this subject by Le Garde, Taylor, Wells, and the Boston Health Department, a total of 759 cartridges having been examined, both by cultures and animal inoculations, all with negative results for *B. tetani*. The only report of the finding of *B. tetani* in cartridges is made by R. N. Connolly, bacteriologist to the board of health of Newark, N. J. He bases his diagnosis, apparently, on the morphology and odor of cultures, and no inoculation of animals is reported. With regard to *B. aerogenes capsulatus*, Wells alone describes an obligate anaërobe which corresponds closely to this organism, but says it seemed to have motility, and it is not identified.

My thanks are due to Dr. W. T. Howard, Jr., and to Dr. Roger G. Perkins, for their valuable suggestions.

CONCLUSIONS

1. *B. aerogenes capsulatus* (Welch) was present in a large proportion of the wads of the three makes of cartridges examined.

2. The wads of the Peters Company, inoculated in rats, guinea-pigs, and rabbits, produced characteristic symptoms of tetanus.

3. The powder of the three varieties of cartridges examined was negative for *B. tetani* and *B. aerogenes capsulatus*.

4. My efforts at isolation of *B. tetani* from the wads have so far been unsuccessful.

5. There is abundant evidence, from clinical observations and animal experiments, that the wads of certain blank cartridges contain *B. tetani*. Dr. Welsh told me that he considered it diagnostic to see an animal in convulsions.

REVIEW

The Chemistry of Commerce, R. K. Duncan. Harper & Bros., 1907. In this new book the author again, as in his "New Knowledge", translates admirably the technical and scientific facts into language easily understood by the layman. This he states to be his object, and he has succeeded well. The chief value of the book is not simply in the facts that are therein stated, nor in the description of the great industries dependent upon chemical science, but in the suggestions for improvement, in the inspiration to greater things, in the call to larger influence.

Although in the main the author does treat of the chemistry of commerce, yet in a few chapters the relation is somewhat far fetched. As an example, a chapter on "Floral Perfumes" treats for the most part on the methods used in obtaining the perfumes from flowers and only at the end records briefly the chemical production of artificial perfumes. Again in the chapter on "Making of Medicines", biology plays a more important part than chemistry. But if this is a fault, it may be largely overlooked because of the intensely interesting things therein recorded.

The author constantly points out the fact that Americans, while excelling in mechanical appliances are far behind in scientific knowledge concerning the basis of their industries, and hence the enormous waste through bye-products of factories. Finally he appeals to the manufacturer for a more scientific business, to the scientist for at least a toleration of research on technical problems, and the Universities to stand sponsor between the two.

The book is one that every manufacturer should read, to gain a knowledge of how the chemist may help him: it is one that every chemist should read to gain inspiration in his work.

R. O. E. D.

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